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(54) A process and an installation for producing a drip irrigation conduit.

(57) For producing a drip irrigation conduit (13) having discrete internally located emitter units (6) bonded at axially spaced apart locations of an internal surface thereof, the irrigation conduit (13) is continuously extruded from an extrusion cross-head (2) at a first outer diameter and a first linear velocity and is drawn off through a calibrator unit (8) to a second and lesser outer diameter at a second linear velocity greater than the first linear velocity, the emitter units (6) being continuously supplied on a carrier member (4) which extends from within the extruder cross-

head (2) to the region of an inlet of the calibrator unit (8). Whilst so supported the emitter units (6) are accelerated so as to attain an emitter unit linear velocity substantially equal to said second linear velocity and are displaced at this velocity into contact with the extruded conduit (13) where the latter has substantially attained its second linear velocity and therefore continue to be displaced whilst still supported in contact with the extruded conduit (13) until the emitter unit (6) is heat welded.

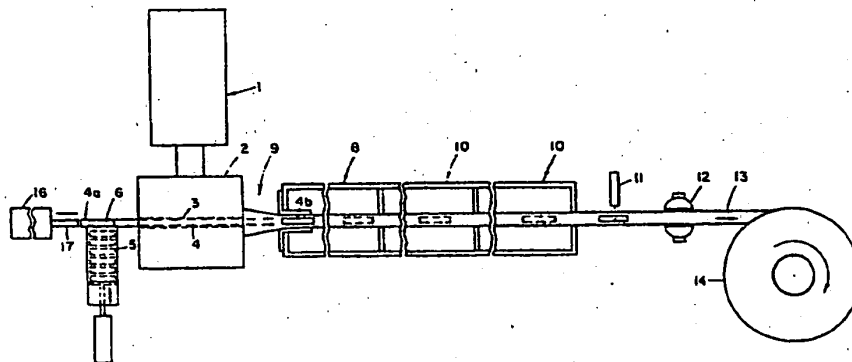


Fig. 1

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## EUROPEAN SEARCH REPORT

Application Number

EP 89 10 9402

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	GB-A-2 057 960 (INDUSTRIAS NEOPLAST SA) * Abstract; figures *	1,3,4,10	B 29 C 47/02 A 01 G 25/02
A	DE-B-2 902 007 (REIFENHÄUSER KG) * Figures *	1,3,4,10	
A,D	US-A-3 981 452 (G. ECKSTEIN) * Abstract; figures *	1,3-5,10	
A,D	US-A-4 307 841 (R. MEHOUDAR et al.) * Abstract; figure 1 *	1,3,4,10	
A	FR-A-2 197 713 (MARUHACHI KASEI KOGYO K.K.) * Figure 3 *	1-5,10	
A	FR-A-1 458 967 (H. GIEHLER) * Figures *	1-5,10	
A	US-A-3 826 285 (F.J. REYNOLDS) * Figure 2 *	1-5,10	
A,D	US-A-2 484 965 (C.E. SLAUGHTER) * Figure 1 *	1,3,4,10	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A,D	US-A-2 575 138 (C.E. SLAUGHTER) * Figure 1 *	1,3,4,10	B 29 C A 01 G
A	US-A-4 191 518 (S. KOJIMOTO et al.) * Figures 4,5 *	1,3,4,10	
The present search report has been drawn up for all claims			
Place of search		Date of completion of search	Examiner
The Hague		17 January 91	BELIBEL C.
<b>CATEGORY OF CITED DOCUMENTS</b>			
X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention		E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document	

# A PROCESS AND AN INSTALLATION FOR PRODUCING A DRIP IRRIGATION CONDUIT

## FIELD OF THE INVENTION

This invention relates to the introduction of elements into a plastic tube during the extrusion thereof and the bonding of these elements to the inner surface of the tube at predetermined locations. The invention relates particularly to a process and an installation for producing a drip irrigation conduit having discrete internally located emitter units bonded at axially spaced apart locations of an internal surface thereof.

## BACKGROUND OF THE INVENTION

The enclosing or encasing of cylindrical objects during the course of the extrusion of a plastic sleeve has long been known, e.g. in the production of covered cables or the like. Furthermore it is known to introduce discrete cylindrical objects into a tube during the course of the extrusion thereof. Thus, for example, in U.S. Patent Specification Serial No. 2,484,965 (Slaughter) there is disclosed a method of making extruded collapsible tubes which essentially consists of extruding a continuous tube by means of an extrusion cross head and successively feeding into the extrusion successive spaced-apart tube closures so that the tube is formed around the closures. Similarly, in U.S. Patent Specification Serial No. 2,575,138 (Slaughter) there is disclosed a process for packaging cylindrical articles within a continuous tube comprising the steps of extruding the tube by means of an extrusion cross head, successively feeding the articles to be packaged through the cross head so as to be enclosed by the tube, the portions of the tube between the successive enclosed articles being subsequently sealed and severed.

In both cases the tube is extruded by an angular extrusion nozzle (known as an extrusion cross head) with the cylindrical objects being successively fed into the cross head by means of an appropriate pusher mechanism.

In completely analogous fashion there is disclosed in U.S. Patent Specification No. 3,981,452 the application of this known process in the production of an irrigation conduit in which are located at predetermined intervals, successive cylindrical units which together with the inner face of the conduit form a plurality of emitter units.

In all cases of the prior art referred to above, the element to be enclosed by the extruded tube, whatever its nature, is of cylindrical shape and is wholly enclosed by the extruded tube.

The present invention, on the other hand, re-

lates particularly to the production of a drip irrigation conduit, wherein the internally bonded emitter units are not of circular cross section extending across the entire periphery of the surrounding conduit, but are of limited depth with the bonded area thereof extending into the conduit for less than half the diameter thereof. Drip irrigation conduits having emitters of this kind are, for example, disclosed in our earlier U.S. Patent No. 4,307,841.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new method and apparatus for the production by extrusion of drip irrigation conduits having internally heat welded emitter units of this kind.

According to one aspect of the present invention, there is provided a process for producing a drip irrigation conduit having internally heat welded emitter units, each emitter unit including a welded area having a transverse, peripheral extent not greater than half the transverse peripheral extent of the conduit, characterised in the steps of:

continuously extruding an irrigation conduit from an extrusion cross head at a first outer diameter and a first linear velocity;

passing the extruded conduit through an intermediate zone and into a calibrator unit so as to be drawn down to a second outer diameter which is less than the first outer diameter and so as to have a second linear velocity greater than the first linear velocity;

supporting said emitter units over a support region coaxial with the extruded conduit and extending from a first end of said support region within the extruder cross-head to an opposite end of said support region within the calibrator unit;

successively accelerating said supported emitter units so as to attain an emitter unit linear velocity substantially equal to said second linear velocity;

displacing each supported emitter unit at said emitter unit linear velocity into contact with said extruded conduit where the conduit has substantially attained said second linear velocity;

displacing each supported emitter unit at said emitter unit linear velocity in contact with the extruded conduit until the emitter unit is heat welded to the conduit at substantially said opposite end;

cooling the extruded conduit and internally heat weld emitter units;

successively determining the location of the heat welded emitter units in the conduit; and aperturing the conduit so as to form respective drip outlets for the emitter units.

According to a second aspect of the present invention there is provided an extrusion installation for use in carrying out this process and characterised in that there is provided:

an extrusion cross-head with an axial bore;

a calibrator unit spaced therefrom by an intermediate region;

drawing-off means located downstream of said calibrator unit for drawing off the extruded conduit through and out of the calibrator unit at a conduit linear velocity;

an emitter carrier element located coaxially with said axial bore having a first end located within said bore and a second opposite end located within said calibrator unit;

emitter feed means for successively feeding emitter units to said carrier element; and

emitter displacement means for successively accelerating said emitter units along said carrier element so as to attain an emitter unit velocity substantially equal to said conduit linear velocity, for displacing said emitter units along said carrier element at said emitter unit velocity in contact with an extruded conduit when the latter has substantially attained said conduit linear velocity and displacing said emitter units along said carrier element until the emitter units are heat welded to the conduit at substantially said opposite end of said carrier element.

According to a third aspect of the present invention there is provided an extrusion installation for use in carrying out this process and characterised in that there is provided:

an extrusion cross-head with an axial bore;

a calibrator unit spaced therefrom by an intermediate region;

drawing-off means located downstream of said calibrator unit for drawing off the extruded conduit through and out of the calibrator unit at a conduit linear velocity;

an emitter carrier element located coaxially with said axial bore having a first end located within said bore and a second opposite end located within said calibrator unit;

emitter feed means for successively feeding emitter units to said carrier element; and

emitter displacement means for displacing said emitter units along said carrier element at an emitter unit velocity substantially equal to said conduit linear velocity in contact with an extruded conduit when the latter has substantially attained said conduit linear velocity.

According to a fourth aspect of the present invention there is provided a process for producing a drip irrigation conduit having internally heat welded emitter units, each emitter unit including a welded area having a transverse, peripheral extent not greater than half the transverse peripheral extent of

the conduit, characterised in the steps of:

continuously extruding an irrigation conduit from an extrusion cross-head at a first outer diameter and a first linear velocity;

5 passing the extruded conduit through an intermediate zone and into a calibrator unit so as to be drawn down to a second outer diameter which is less than the first outer diameter and so as to have a second linear velocity greater than the first linear velocity;

10 supporting said emitter units over a support region coaxial with the extruded conduit and extending from a first end of said support region within the extruder cross-head to an opposite end of said support region within the calibrator unit;

15 displacing each supported emitter unit at an emitter unit linear velocity substantially equal to said second linear velocity into contact with said extruded conduit where the conduit has substantially attained said second linear velocity;

20 cooling the extruded conduit and internally heat welded emitter units;

successively determining the location of the heat welded emitter units in the conduit; and

25 aperturing the conduit so as to form respective drip outlets for the emitter units.

By virtue of the process and apparatus in accordance with the invention, it is possible to ensure that the extruded conduit is contacted, whilst still in a semi-molten malleable state, by successive emitter units which are accelerated from rest so as to attain a displacement rate substantially equal to the conduit linear velocity whereupon the emitter units contact the conduit, and are at all times supported until they are fully heat welded to the conduit, thereby ensuring the effective heat welding of the emitter units to the conduit as part of the overall extrusion process without disturbing the extrusion process or overall characteristics of the conduit.

## SUMMARY OF THE DRAWINGS

45 For a better understanding of the present invention and to show how the same may be carried out in practice, reference will now be made to the accompanying drawings in which:

Fig. 1 is a schematic view of a drip irrigation conduit extrusion installation in accordance with the present invention;

Fig. 2 is a longitudinally sectioned view, on an enlarged scale, of a portion of the installation shown in Fig. 1;

55 Fig. 3 is a cross-sectional view of the installation shown in Fig. 2 taken along the line III-III; and

Figs. 4a, 4b and 4c show cross-sectional views of various modifications of a detail of the installation shown in Figs. 2 and 3.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

As seen in Fig. 1 of the drawings, the installation comprises an extruder 1 provided with an extrusion cross-head 2 having a coaxial bore 3 through which extends an elongated emitter carrier 4. An upstream end 4a of the carrier 4 is juxtaposed with respect to an emitter stack 5 from which emitters 6 can be successively fed on to the upstream end of the carrier 4.

A calibration and cooling unit 8 is located downstream from the extrusion cross-head 2 and is spaced therefrom by an intermediate region 9. A downstream end 4b of the carrier 4 projects into the unit 8. Downstream of the unit 8 is a plurality of further cooling units 10 followed by a conduit aperturing station 11, caterpillar type drawing off means 12 for drawing off an extruded conduit 13 and a conduit coiling mechanism 14.

An emitter displacement means 16 is located upstream of the upstream end 4a of the carrier 4 and is provided with a pusher 17 aligned with the carrier 4. The displacement means can be, for example, mechanically, electro-mechanically, or hydraulically operated so as to displace the pusher 17 at a rate which is at all times controlled in accordance with operational requirements.

Reference will now be made to Figs. 2 and 3 of the drawings for a more detailed description of the extrusion cross-head 2, the carrier 4 and the calibration and cooling unit 8. The extrusion cross-head 2 comprises a mandrel 21 having an outwardly directed flange 21a screw bolted to a cylindrical sleeve 22 in which is screw fitted a die element 23, there being defined between the die element 23 and the mandrel 21 a spacing from which is extruded the conduit 13.

Spaced from the extrusion cross-head 2 by an intermediate region 9 is the calibrator and cooling unit 8 comprising an apertured calibrator tube 24 formed integrally with the calibrator flange 25 which is secured to the walls of the unit 8, the latter being filled with cooling water under a vacuum.

Extruding through the axial bore 3 of the extrusion cross-head 2, the intermediate region 9 and into an axial bore 26 of the calibrator tube 24 is the elongated carrier 4 which, as seen in Fig. 3 of the drawings, is formed with a pair of elongated ducts 27 which pass along the length of the carrier and serve for the passage of cooling water from an inlet nipple 28.

The carrier 4 is formed with an upper, axially directed rib 29 adapted to fit into a corresponding recess formed in a base of an emitter 6 so as to support and align the latter. The carrier 4 is supported at the upstream end 4a thereof by a support column 30.

In operation, plastic material 31 passes from the extruder 1 into the extrusion cross-head 2 so as to emerge therefrom at a first linear velocity as an extruded, wide diameter, molten conduit 13. Under the traction force exerted by the drawing-off means 12, the conduit 13 passes through the narrower opening of the calibrator tube 24 with its diameter and wall thickness being reduced to substantially their final dimensions and at a second and higher linear velocity. As the extruded conduit 13 passes at this second linear velocity through the calibrator unit 8 and subsequent cooling units 10 it cools down until it reaches its final set state.

At the same time, successive emitters 6 are fed on to the upstream end 4a of the carrier 4 and are displaced by the pusher 17 along the carrier 4 so as to be accelerated up to a linear velocity substantially corresponding to the second linear velocity of the conduit until the upper surface of each successive emitter 6 contacts a spaced apart, inner surface location of the conduit when the latter is still in a semi-molten state in the region of an inlet to the calibrator unit 8 and when the conduit has substantially reached its second linear velocity. Each emitter 6 thus begins to become heat welded to the inner surface of the conduit whilst being displaced along the carrier at a linear velocity substantially equal to the second linear velocity of the conduit until, by the time the emitter has reached the end of the carrier, it is firmly heat welded to the conduit.

The displacement of the emitters 6 by the pusher 7 can be effected directly or indirectly, in the latter case via one or more intermediate elements or emitters.

It can be seen that at all times the carrier element never contacts the extruded conduit and supports the emitters at surfaces thereof remote from those surfaces of the emitters which are ultimately heat welded to the conduit.

The spacing apart of the emitters 6 within the conduit 13 is determined by time intervals between the successive displacements of the emitters 6 along the carrier 4.

Once the emitters 6 have been firmly heat welded to the conduit 13 and after the latter has emerged from the final cooling unit 9, the location of the emitter units 6 within the conduit 13 are sensed and the conduit 13 then passes the aperturing station 11 where it is apertured in positions corresponding to the emitter outlets. The conduit 13 with the internally heat welded emitters drawn

off by the drawing-off mechanism is coiled by the coiling mechanism 14.

Whilst in the embodiment shown in Figs. 2 and 3 of the drawings the carrier 4 is so constructed as to have the emitter units 6 supported thereby and aligned thereon (further embodiments illustrating this being shown in Figs. 4a and 4b of the drawings), the carrier construction can be so designed that emitter units are effectively suspended from and aligned by the carrier. I

Furthermore, whilst in the embodiment specifically described above the carrier 4 projects into the calibrator unit 8 so as to ensure that contact between the emitter units and the extruded conduit and the full heat welding thereof take place when the latter has achieved its final substantially constant velocity, the carrier 4 may alternatively extend only to the region of the inlet of the carrier 4. This situation is less ideal with regard to the ultimate quality of the product compared with that described in detail above wherein it is ensured that the heat welding of the emitters 6 to the conduit 13 does not result in undue stressing of the conduit and does not interfere with the stability of the extrusion process or with the quality of the extruded conduit.

#### Claims

1. A process for producing a drip irrigation conduit having internally heat welded emitter units, each emitter unit including a welded area having a transverse, peripheral extent not greater than half the transverse peripheral extent of the conduit, characterised in the steps of:  
continuously extruding an irrigation conduit from an extrusion cross head at a first outer diameter and a first linear velocity;  
passing the extruded conduit through an intermediate zone and into a calibrator unit so as to be drawn down to a second outer diameter which is less than the first outer diameter and so as to have a second linear velocity greater than the first linear velocity;  
supporting said emitter units over a support region coaxial with the extruded conduit and extending from a first end of said support region within the extruder cross-head to an opposite end of said support region within the calibrator unit;  
successively accelerating said supported emitter units so as to attain an emitter unit linear velocity substantially equal to said second linear velocity;  
displacing each supported emitter unit at said emitter unit linear velocity into contact with said extruded conduit where the conduit has substantially attained said second linear velocity;  
displacing each supported emitter unit at said emitter unit linear velocity in contact with the extruded

conduit until the emitter unit is heat welded to the conduit at substantially said opposite end;  
cooling the extruded conduit and internally heat weld emitter units;

successively determining the location of the heat welded emitter units in the conduit; and  
aperturing the conduit so as to form respective drip outlets for the emitter units.

2. A modification of the process according to Claim 1 characterised in that the opposite end of the support region is located in the region of an inlet of the calibrator unit.

3. A process for producing a drip irrigation conduit having internally heat welded emitter units, each emitter unit including a welded area having a transverse, peripheral extent not greater than half the transverse peripheral extent of the conduit, characterised in the steps of:

continuously extruding an irrigation conduit from an extrusion cross-head at a first outer diameter and a first linear velocity;

passing the extruded conduit through an intermediate zone and into a calibrator unit so as to be drawn down to a second outer diameter which is less than the first outer diameter and so as to have a second linear velocity greater than the first linear velocity;

supporting said emitter units over a support region coaxial with the extruded conduit and extending from a first end of said support region within the extruder cross-head to an opposite end of said support region within the calibrator unit;

displacing each supported emitter unit at an emitter unit linear velocity substantially equal to said second linear velocity into contact with said extruded conduit where the conduit has substantially attained said second linear velocity;

cooling the extruded conduit and internally heat welded emitter units;

successively determining the location of the heat welded emitter units in the conduit; and  
aperturing the conduit so as to form respective drip outlets for the emitter units.

4. An extrusion installation for producing a drip irrigation conduit (13) in accordance with the process according to Claim 1 and characterised in that there is provided:

an extrusion cross-head (2) with an axial bore (3);

a calibrator unit (8) spaced therefrom by an intermediate region (9);

drawing-off means (12) located downstream of said calibrator unit (8) for drawing off the extruded conduit (13) through and out of the calibrator unit (8) at a conduit linear velocity;

an emitter carrier element (4) located coaxially with said axial bore (3) having a first end (4a) located within said bore and a second opposite end (4b) located within said calibrator unit (8);

emitter feed means (16) for successively feeding emitter units (6) to said carrier element (4); and emitter displacement means (17) for successively accelerating said emitter units (6) along said carrier element (4) so as to attain an emitter unit velocity substantially equal to said conduit linear velocity, for displacing said emitter units (6) along said carrier element (4) at said emitter unit velocity in contact with an extruded conduit (13) when the latter has substantially attained said conduit linear velocity and displacing said emitter units (6) along said carrier element (4) until the emitter units (6) are heat welded to the conduit (13) at substantially said opposite end (4b) of said carrier element (4).

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5. An extrusion installation according to Claim 4 characterised in that said displacement means (16) includes a displaceable pusher (17) aligned with said carrier element (4) and adapted to engage an emitter (6) carried by said carrier element.

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6. An extrusion installation according to Claim 4 characterised in that said carrier element (4) is provided with cooling fluid transmission means (27).

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7. An extrusion installation according to Claim 4 characterised in that said carrier element (4) is designed to support said emitters (6).

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8. An extrusion installation according to Claim 4 characterised in that said carrier element (4) is designed to have said emitters (6) suspended therefrom.

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9. A modification of the extrusion installation according to Claim 4 characterised in that the opposite end (4b) of the carrier element (4) is located in the region of an inlet of the calibrator unit (8).

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10. An extrusion installation for producing a drip irrigation conduit (13) in accordance with the process according to Claim 1 and characterised in that there is provided:

40  
an extrusion cross-head (2) with an axial bore (3);  
a calibrator unit (8) spaced therefrom by an intermediate region (9);

45  
drawing-off means (12) located downstream of said calibrator unit (8) for drawing off the extruded conduit (13) through and out of the calibrator unit (8) at a conduit linear velocity;

50  
an emitter carrier element (4) located coaxially with said axial bore (3) having a first end (4a) located within said bore (3) and a second opposite end (4b) located within said calibrator unit (8);

55  
emitter feed means (16) for successively feeding emitter units (6) to said carrier element (4); and emitter displacement means (17) for displacing said emitter units (6) along said carrier element (4) at an emitter unit velocity substantially equal to said conduit linear velocity in contact with an extruded conduit (13) when the latter has substantially attained said conduit linear velocity.



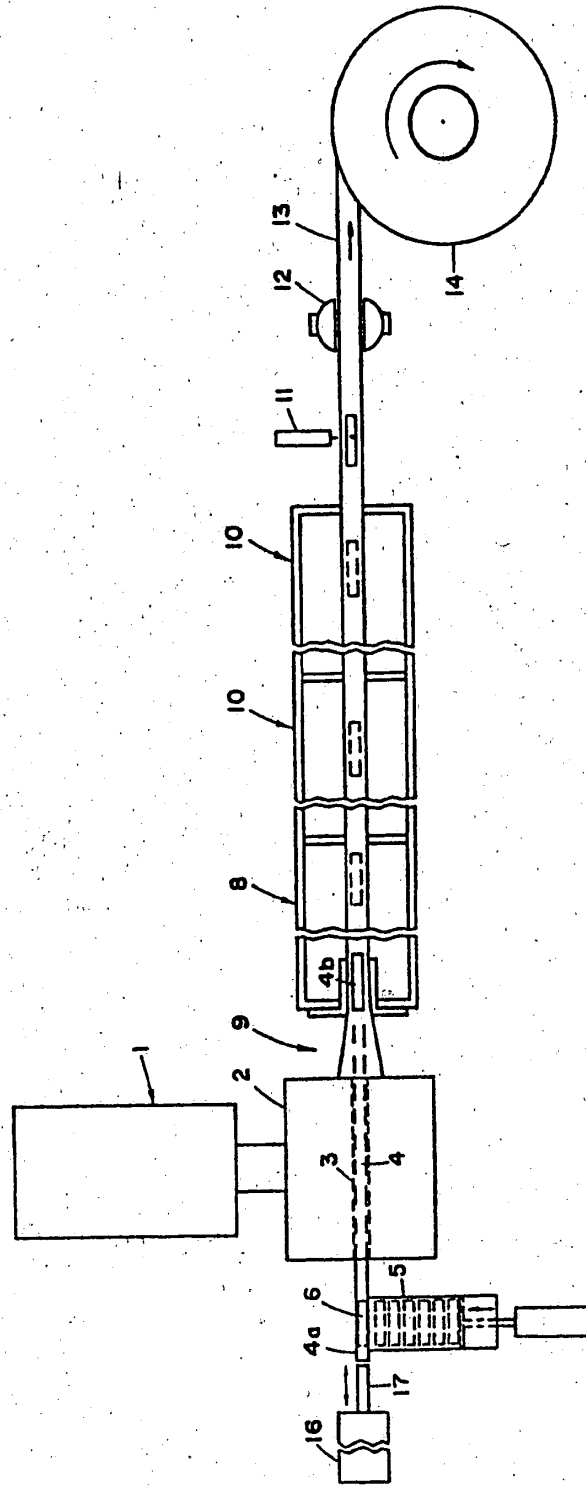
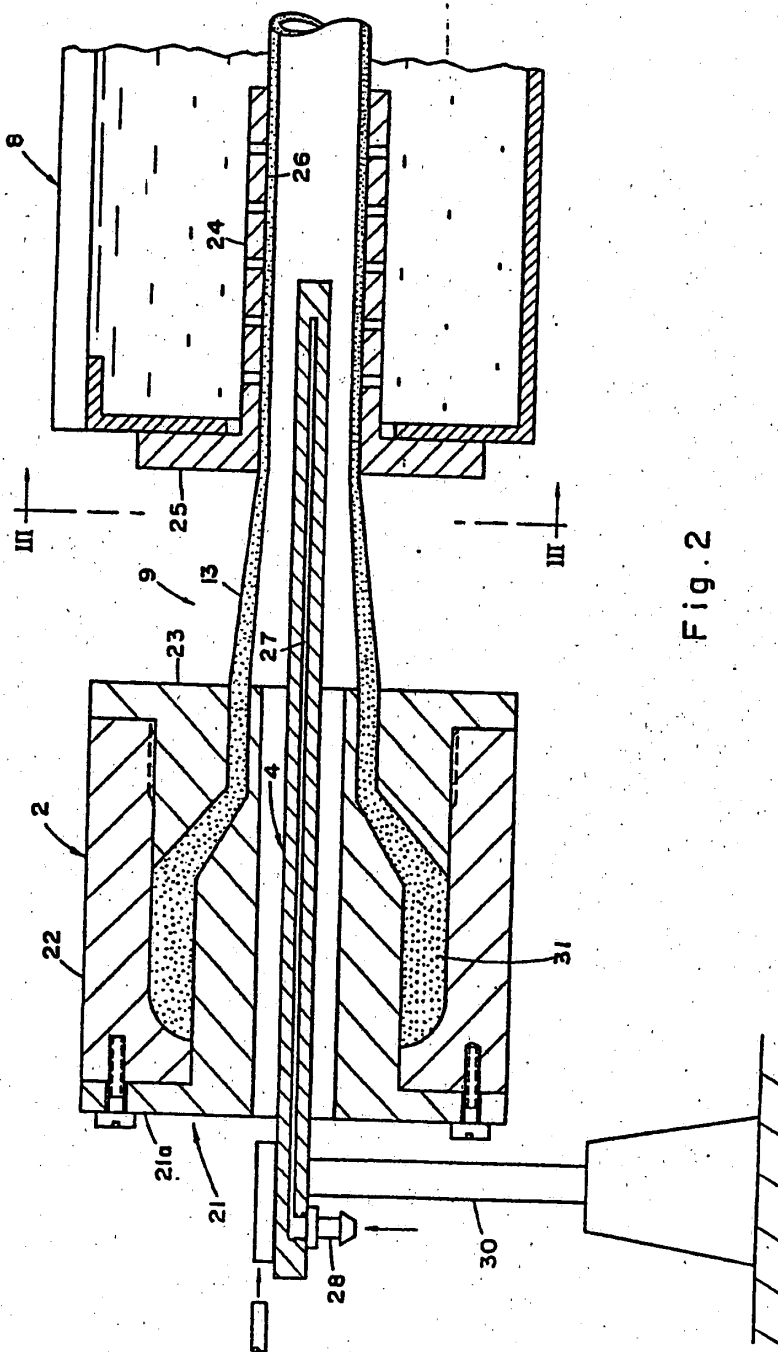


Fig. 1



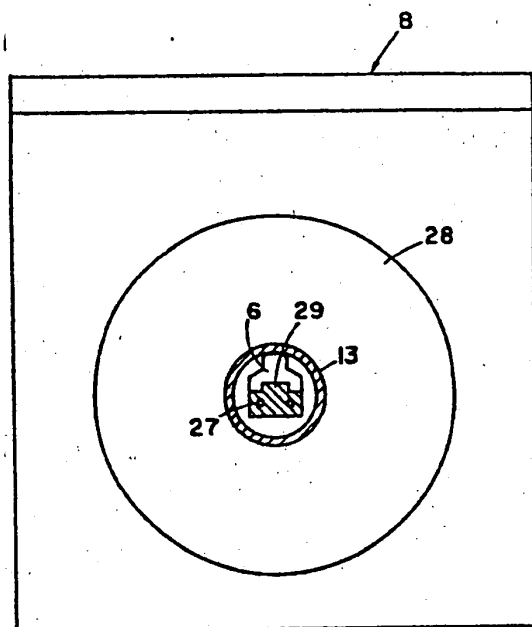


Fig. 3



a



b

Fig. 4